Computer Vision Algorithms in the Detection of Diabetic Foot Ulceration: A New Paradigm for Diabetic Foot Care?

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Diabetic foot ulcers (DFUs) and other foot pathologies are highly prevalent in people with diabetes, especially in patients with the secondary complications of peripheral neuropathy and/or peripheral vascular disease [1]. The development of DFUs involves changes in the appearance of the foot over time, however, many subtle changes in foot shape, texture and colour will likely be undetectable by human vision until a DFU is established. Advanced computer vision algorithms have be applied in the medical field to detect subtle signs to differentiate the type of tumours [2] subtle changes in facial features – such as fine wrinkles on the face [3] and micro facial movements [4] – where some of these features are not detectable by human vision. We see the opportunity to apply computer vision algorithms to help in the early detection of key pathological changes in the diabetic foot leading to the development of a DFU.

To implement this novel approach over time, however, photographs of the foot need to be taken and carefully standardized for key specific conditions – distance of image capture from the foot and orientation of the camera relative to the foot. Using a standard human 'manually-operated' camera, however, will lead to inconsistency in relation to these conditions, and such errors will likely be exaggerated when different operators are involved across different clinical sites. To increase the reliability of the captured foot image with a view to applying computer vision algorithms for early detection and monitoring of DFUs in the future, we have developed a mobile app for the iPad called 'FootSnap' to standardize image capture of the plantar surface of diabetic feet (Fig. 1).

We have tested the reliability of FootSnap in a sample of healthy feet with two different operators and this image capture app has shown excellent reliability both within and between operators. The high reproducibility of captured foot images demonstrated that the app was successful in standardizing the acquisition of plantar foot photographs for the key parameters of distance and orientation relative to the foot. This is important for successfully standardizing foot images over time, i.e., repeated photographs of the same patient's foot and across different clinical sites when different operators are involved. The next stage of our work will be to test FootSnap's reliability in diabetic feet and compare the reproducibility of the captured images with those in healthy feet.

Standardization of foot photographs captured by FootSnap is the first important step in enabling the implementation of advanced computer vision algorithms with pictures of diabetic feet, which can then be used for monitoring changes in diabetic foot shape, texture and colour during longitudinal clinical trials, or as part of state-of-the-art clinical monitoring procedures. This exciting development is the result of a highly multidisciplinary team involving clinicians and researchers in the fields of diabetes, computer vision and biomechanics. Over the next decade, we hypothesize that computer vision algorithms may facilitate a major step forwards in the prevention of diabetic foot ulcers, ushering in a new paradigm of pre-emptive diabetic foot care.

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(a) (b)

Figure 1. (a) Illustration of the experimental set-up for using FootSnap; and (b) An image captured by the operator with the white outline around the foot generated using computer vision algorithms for image standardization.